CLAIMS

1. A three dimensional inspection method for inspecting ball array devices having a plurality of balls, wherein the ball array device is positioned in an optical system, the inspection method comprising the steps of:

a) illuminating at least one ball on the ball array device;

b) disposing a sensor, a first optical element and a second optical element in relation to the ball array device so that the sensor obtains at least two differing views of the at least one ball, the sensor providing an output representing the at least two differing views;

and

c) processing the output using a triangulation method to calculate a three dimensional position of the at least one ball with reference to a pre-calculated calibration plane.

2. The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

3. The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein an XY measurement value is

proportional to a Z measurement value.

4. The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein a Y measurement value is proportional to a Z measurement value.

5. The three dimensional inspection method of claim 1 wherein the triangulation method is based on determining a center of the ball in a first view and determining a ball top location in a second view.

6. The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

7. The three dimensional inspection method of claim 1 wherein the second optical element comprises a mirror.

8. The three dimensional inspection method of claim 1 wherein the second optical element comprises a prism.

9. The three dimensional inspection method of claim 1 wherein one of the at least two differing views is obtained at a low angle of view.

10. The three dimensional inspection method of claim 1 wherein the sensor and the second optical element are positioned to receive light from different angles relative to the calibration plane.

11. The three dimensional inspection method of claim 1 wherein the sensor comprises a charged coupled device array.

12. The three dimensional inspection method of claim 1 wherein the sensor comprises a complementary metal oxide semiconductor device array.

13. The three dimensional inspection method of claim 1 wherein the processing step further includes the step of applying grayscale edge detection to locate ball positions.

14. The three dimensional inspection method of claim 1 wherein the processing step further includes the step of applying threshold analysis.

15. The three dimensional inspection method of claim 1 wherein the first optical element comprises a lens.

16. The three dimensional inspection method of claim 1 wherein the first optical element comprises a pin-hole lens.

17. The three dimensional inspection method of claim 1 wherein the first optical element comprises a plurality of lens elements.

18. The three dimensional inspection method of claim 1 wherein the first optical element comprises a telecentric lens.

19. The three dimensional inspection method of claim 1 wherein the ball array devices comprise ball grid array devices.

20. The three dimensional inspection method of claim 1 wherein the ball array devices comprise bump on wafer devices.

21. The three dimensional inspection method of claim 1 wherein the step of processing the output is carried out on a personal computer.

22. The three dimensional inspection method of claim 1 wherein the sensor includes a solid state sensor array.

23. The three dimensional inspection method of claim 1 wherein one of the views comprises a segment having a crescent shape.

24. A three dimensional inspection method for ball array devices having a plurality of balls, the method comprising the steps of:

a) illuminating the ball array device;

b) disposing a sensor to receive light at a first angle relative to the ball array device;

c) positioning a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball array device;

d) disposing a second optical element to receive light at a second angle different from the first angle and to transmit a second view of the ball array device to the sensor;

e) transmitting image information from the sensor; and

f) processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to a pre-calculated calibration plane.

25. The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

26. The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an XY measurement value is proportional to

a Z measurement value.

27. The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein a Y measurement value is proportional to a Z measurement value.

28. The three dimensional inspection method of claim 24 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

29. The three dimensional inspection method of claim 24 wherein the second optical element comprises a mirror.

30. The three dimensional inspection method of claim 24 wherein the second optical element comprises a prism.

31. The three dimensional inspection method of claim 24 wherein the step of illuminating comprises the step of illuminating with a ring light.

32. The three dimensional inspection method of claim 24 wherein the step of illuminating comprises the step of illuminating with a plurality of light emitting diodes.

33. The three dimensional inspection method of claim 24 wherein the step of illuminating comprises the step of illuminating with reflected light.

34. The three dimensional inspection method of claim 24 wherein the sensor comprises a charged coupled device array.

35. The three dimensional inspection method of claim 24 wherein the sensor comprises a complementary metal oxide semiconductor device array.

36. The three dimensional inspection method of claim 24 wherein the ball array devices comprise ball grid array devices.

37. The three dimensional inspection method of claim 24 wherein the ball array devices comprise bump on wafer devices.

38. The three dimensional inspection method of claim 24 wherein the processing step further includes the step of applying grayscale edge detection to locate ball positions.

39. The three dimensional inspection method of claim 24 wherein the processing step further includes the step of applying threshold analysis.

40. The three dimensional inspection method of claim 24 wherein the first optical element comprises a lens.

41. The three dimensional inspection method of claim 24 wherein the first optical element comprises a pin-hole lens.

42. The three dimensional inspection method of claim 24 wherein the first optical element comprises a plurality of lens elements.

43. The three dimensional inspection method of claim 24 wherein the first optical element comprises a telecentric lens.

44. The three dimensional inspection method of claim 24 wherein the step of illuminating comprises the step of illuminating with a ring light.

45. The three dimensional inspection method of claim 24 wherein the sensor includes a solid state sensor array.

46. The three dimensional inspection method of claim 24 wherein the step of processing is carried out on a personal computer.

47. The three dimensional inspection method of claim 24 wherein the second optical element reflects a view to the sensor where at least one ball of the ball array device exhibits a crescent

shape.

48. A three dimensional inspection method for ball array devices having a plurality of balls, the method comprising the steps of:

a) illuminating a ball array device;

b) disposing a sensor to receive light at a first angle relative to the ball array device, wherein the sensor includes a solid state sensor array;

c) disposing a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball array device;

d) disposing a second optical element to receive light at a second angle different from the first angle, and to transfer a second view of the ball array device to the sensor;

e) transmitting image information representing the first view and the second view; and

f) processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to a pre-calculated calibration plane, wherein the calibration plane comprises a coordinate system having X, Y and Z axes, and wherein an X measurement value is proportional to a Z measurement value.

49. The three dimensional inspection method of claim 48 wherein an XY measurement value is proportional to a Z measurement value.

50. The three dimensional inspection method of claim 48 wherein a Y measurement value is proportional to a Z measurement value.

51. The three dimensional inspection method of claim 48 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

52. The three dimensional inspection method of claim 48 wherein the processing step further includes the step of applying grayscale edge detection to locate ball positions.

53. The three dimensional inspection method of claim 48 wherein the processing step further includes the step of applying threshold analysis.

54. The three dimensional inspection method of claim 48 wherein the step of illuminating comprises the step of illuminating with a plurality of light emitting diodes.

55. The three dimensional inspection method of claim 48 wherein step of illuminating comprises the step of illuminating with reflected light.

56. The three dimensional inspection method of claim 48 wherein the ball array devices comprise ball grid array devices.

57. The three dimensional inspection method of claim 48 wherein the ball array devices comprise bump on wafer devices.

58. The three dimensional inspection method of claim 48 wherein the solid state sensor array includes a charged coupled device array.

59. The three dimensional inspection method of claim 48 wherein the solid state sensor array includes a complementary metal oxide semiconductor array.

60. The three dimensional inspection method of claim 48 wherein the second optical element comprises a mirror.

61. The three dimensional inspection method of claim 48 wherein the second optical element comprises a prism.

62. The three dimensional inspection method of claim 48 wherein the second view comprises a segment having a crescent shape.

63. The three dimensional inspection method of claim 48 wherein

the image acquisition method comprises a frame grabber.

64. The three dimensional inspection method of claim 48 wherein the step of processing the output is carried out on a personal computer.

65. The three dimensional inspection method of claim 48 wherein the first optical element comprises a lens.

66. The three dimensional inspection method of claim 48 wherein the first optical element comprises a pin-hole lens.

67. The three dimensional inspection method of claim 48 wherein the first optical element comprises a plurality of lens elements.

68. The three dimensional inspection method of claim 48 wherein the first optical element comprises a telecentric lens.

69. A three dimensional inspection method for ball array devices having a plurality of balls, the method comprising the steps of:

a) measuring a calibration plate to determine a calibration plane;

b) illuminating a ball array device;

c) disposing a sensor to receive light at a first angle relative to the ball array device, wherein the sensor includes a solid

state sensor array;

d) disposing a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball array device;

e) disposing a second optical element to receive light at a second angle different from the first angle, and to transfer a second view of the ball array device to the sensor;

f) transmitting image information representing the first view and the second view; and

g) processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to the calibration plane, wherein the calibration plane comprises a coordinate system having X, Y and Z axes, and wherein an X measurement value is proportional to a Z measurement value.

70. A three dimensional inspection process for ball array devices having a plurality of balls, wherein the ball array device is positioned in a fixed optical system, the process comprising the steps of:

a) illuminating the ball array device;

b) taking a first image of the ball array device with a camera disposed in a fixed focus position relative to the ball array device to obtain a circular doughnut shape image from at least one ball;

c) taking a second image of the ball array device with an optical element disposed in a fixed focus position relative to the ball array device to transmit a side view image of the at least one ball to the camera; and

d) processing the first image and the second image using a triangulation method to calculate a three dimensional position of the at least one ball with reference to a pre-calculated calibration plane.

71. The three dimensional inspection process of claim 70 wherein the second image comprises a segment having a crescent shape.

72. The three dimensional inspection process of claim 70 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

73. The three dimensional inspection process of claim 70 wherein the triangulation method to calculate a three dimensional position of the at least one ball is based on determining a center of the ball in the first image and determining a ball top location in the second image.

74. The three dimensional inspection process of claim 70 wherein the pre-calculated calibration plane is defined through the step

of measuring a calibration pattern.

75. The three dimensional inspection process of claim 70 wherein the optical element comprises a mirror.

76. The three dimensional inspection process of claim 70 wherein the second image is obtained at a low angle of view.

77. The three dimensional inspection process of claim 70 wherein the camera and the optical element are fixed at different angles relative to the calibration plane.

78. The three dimensional inspection process of claim 70 wherein the camera comprises a charged coupled device array.

79. The three dimensional inspection process of claim 70 wherein the step of processing the first image and the second image further comprises employing grayscale edge detection to locate ball positions.

80. The three dimensional inspection process of claim 70 wherein the step of illuminating the ball array device further comprises employing diffuse illumination.

81. The three dimensional inspection process of claim 70 wherein

the ball array devices comprise ball grid array devices.

82. The three dimensional inspection process of claim 70 wherein the ball array devices comprise bump on wafer devices.

83. The three dimensional inspection process of claim 70 wherein the triangulation method uses state values derived from the ball array device.

84. The three dimensional inspection process of claim 1 wherein the triangulation method uses state values derived from the ball array device.

85. The three dimensional inspection process of claim 24 wherein the triangulation calculations use state values derived from the ball array device.

86. The three dimensional inspection process of claim 48 wherein the triangulation calculations use state values derived from the ball array device.

87. The three dimensional inspection method of claim 70 wherein the processing step further includes the step of applying threshold analysis.

88. The three dimensional inspection method of claim 70 wherein the sensor comprises a charged coupled device array.